

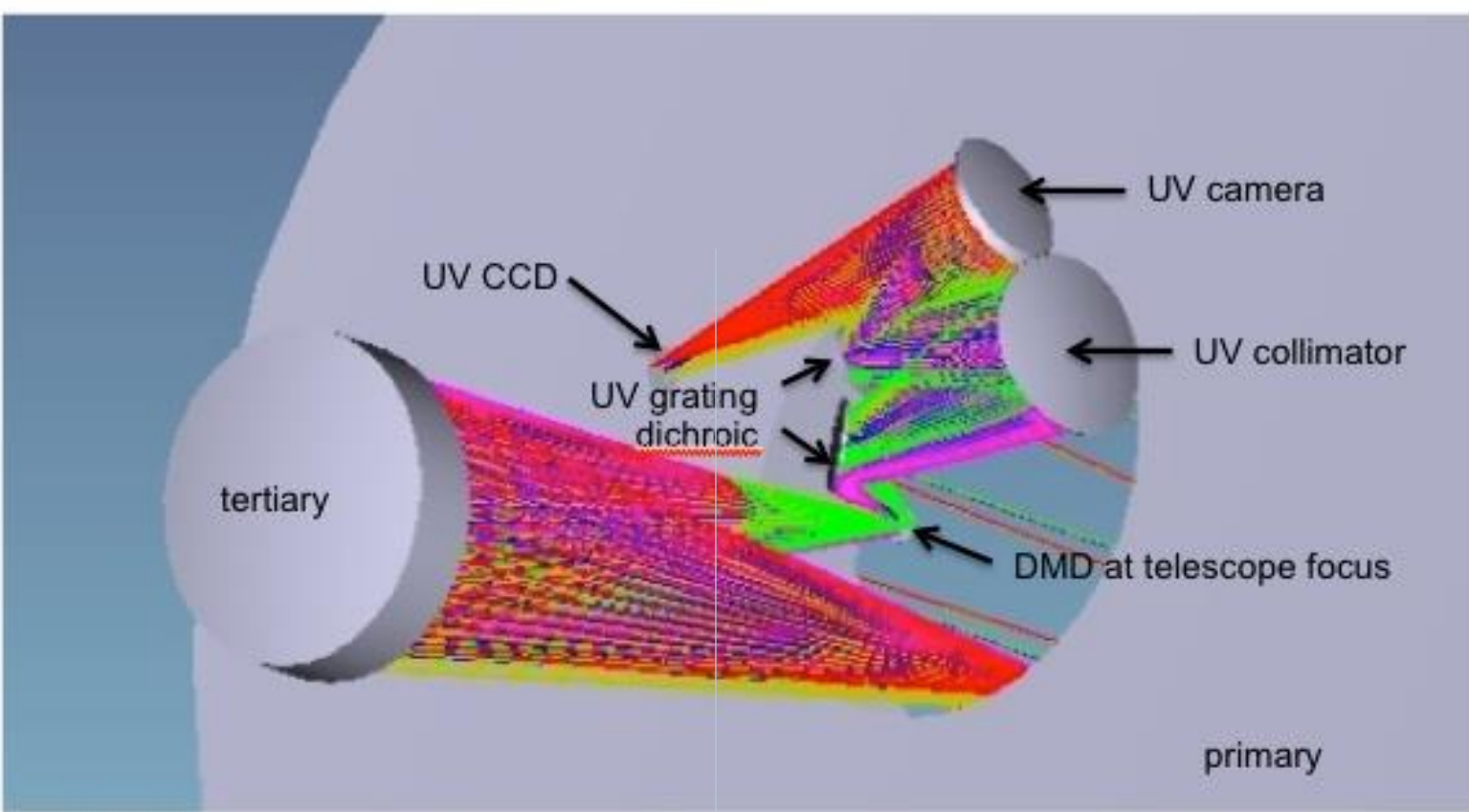
**SPIE.**

<sup>1</sup> NASA-GSFC, <sup>2</sup>Rochester Institute of Tech., <sup>3</sup> Space Telescope Science Institute

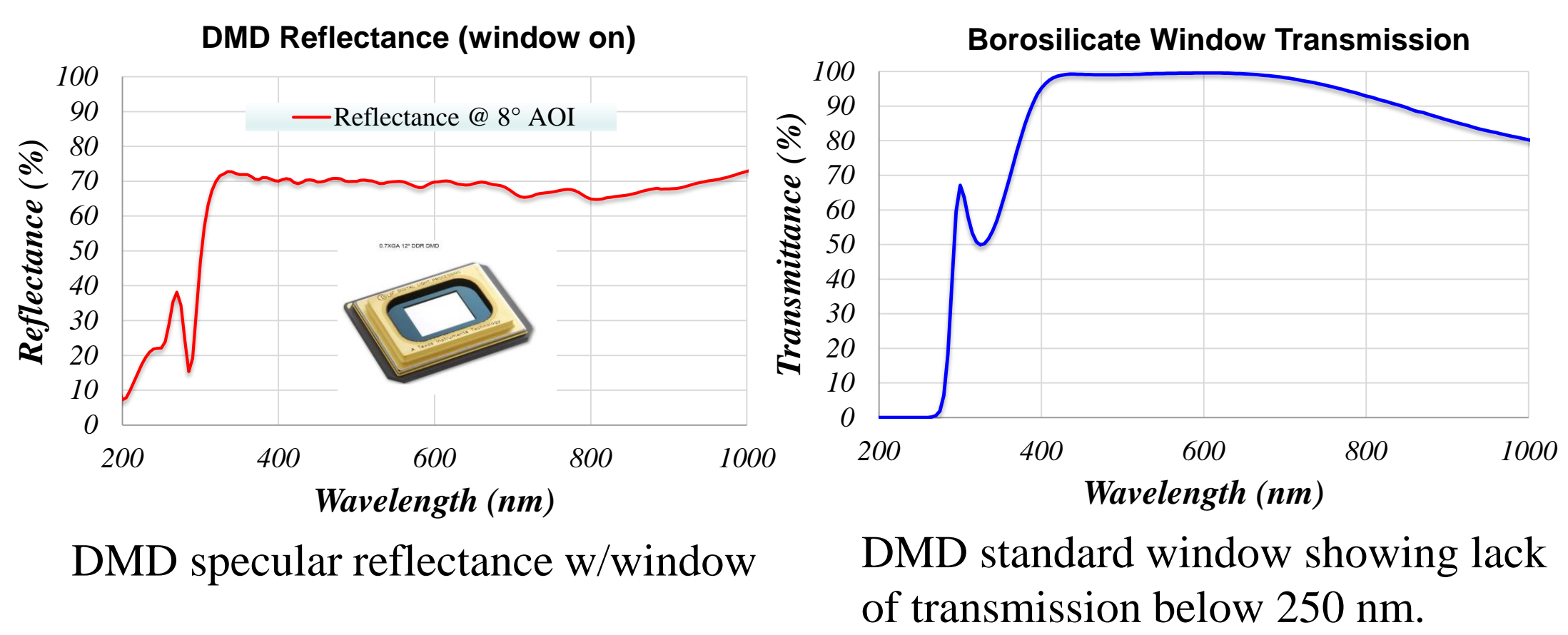
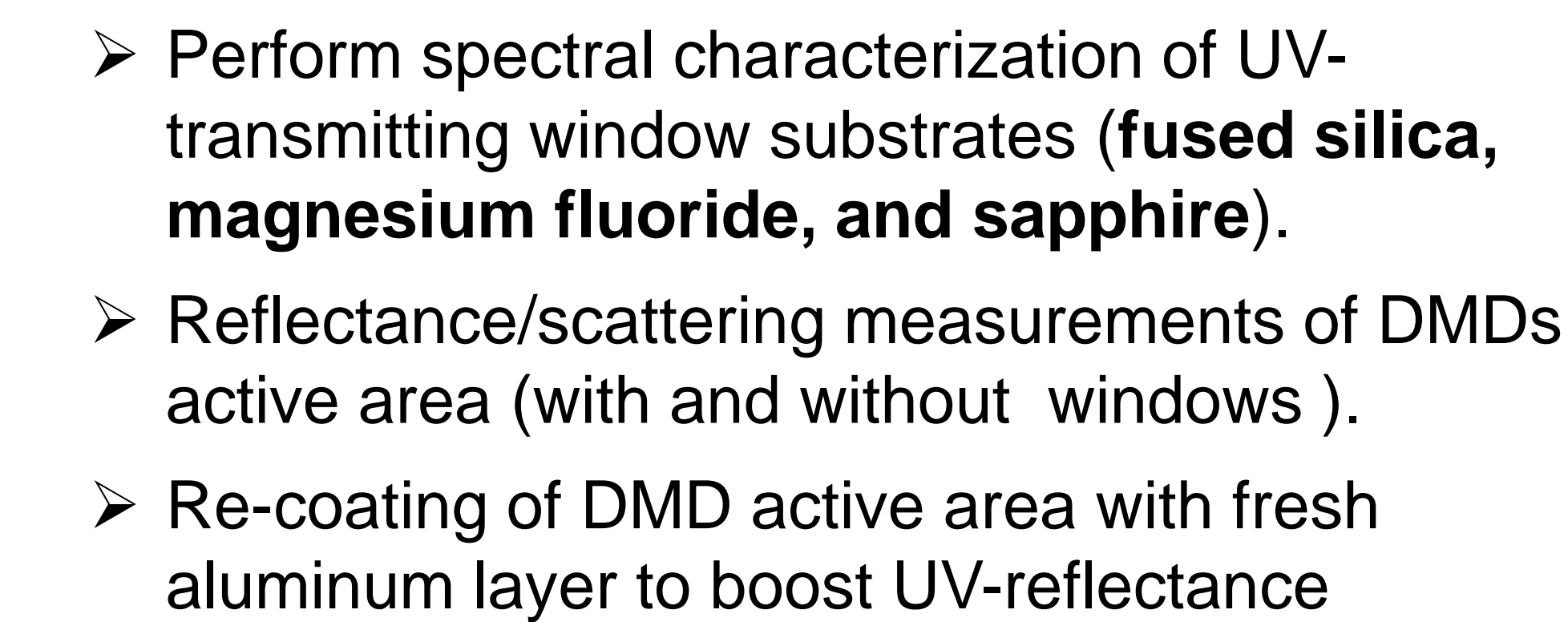
## METHODS

## RESULTS

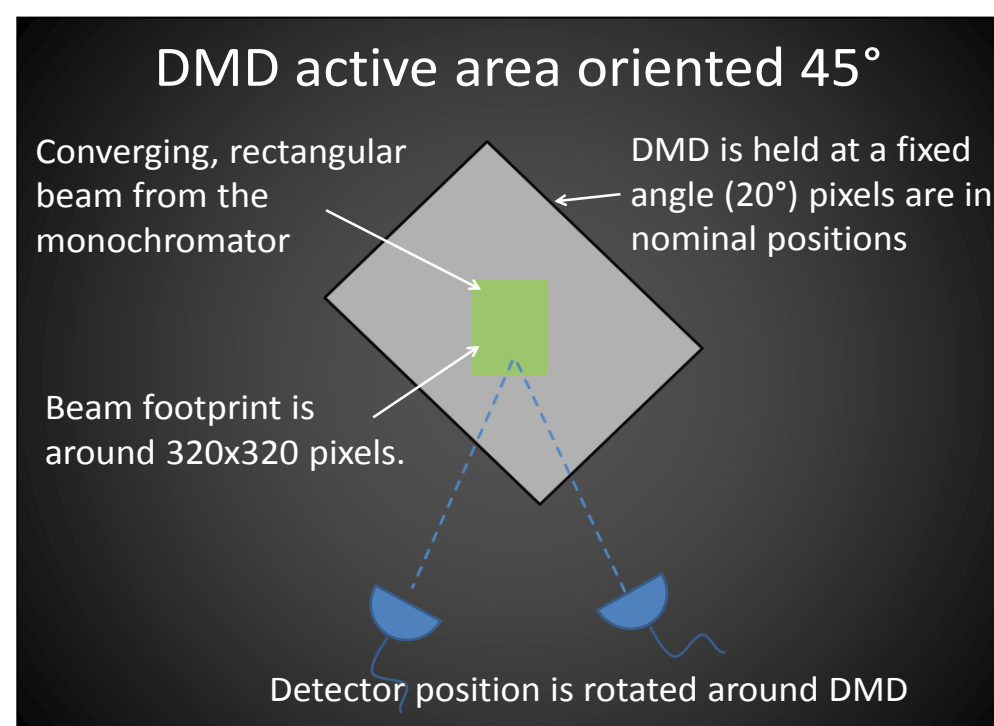
Digital Micro-mirror Devices (DMDs) have been identified as an alternative to microshutter arrays for space-based multi-object spectrometers (MOS). Specifically, the MOS at the heart of a proposed Galactic Evolution Spectroscopic Explorer (GESE) that uses the DMD as a reprogrammable slit mask. Unfortunately, the protective borosilicate windows limit the use of DMDs in the UV and IR regimes, where the glass has insufficient throughput. In this work, we present our efforts to replace standard DMD windows with custom windows made from UV-grade fused silica, Low Absorption Optical Sapphire (LAOS) and magnesium fluoride. We present reflectance measurements of the antireflection coated windows and a reflectance study of the DMDs active area (window removed). Furthermore, we investigated the long-term stability of the DMD reflectance and recoating device with fresh Al coatings.



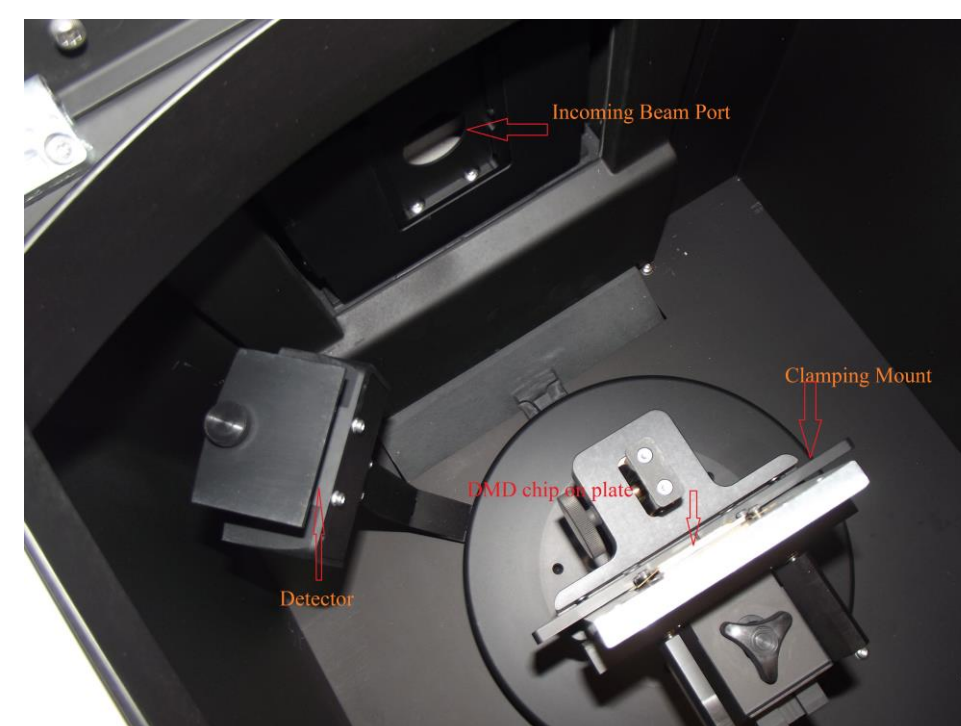
**Mission concept of a 1.2-1.5 meter wide-field telescope design showing a single DMD-based slit selector at the telescope focus.**



## Cary 5000 reflectance/Scattering Measurements



DMD edge orientation is 45° relative to monochromator beam footprint.

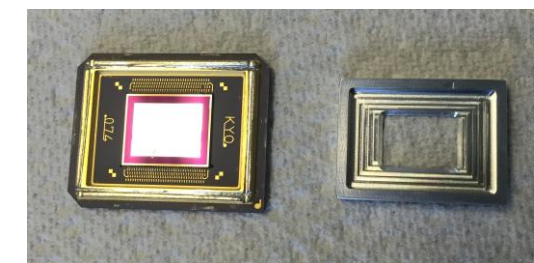


Top view of DMD mounted in spectrometer  
sample compartment

## Physical Vapor Deposition Chamber

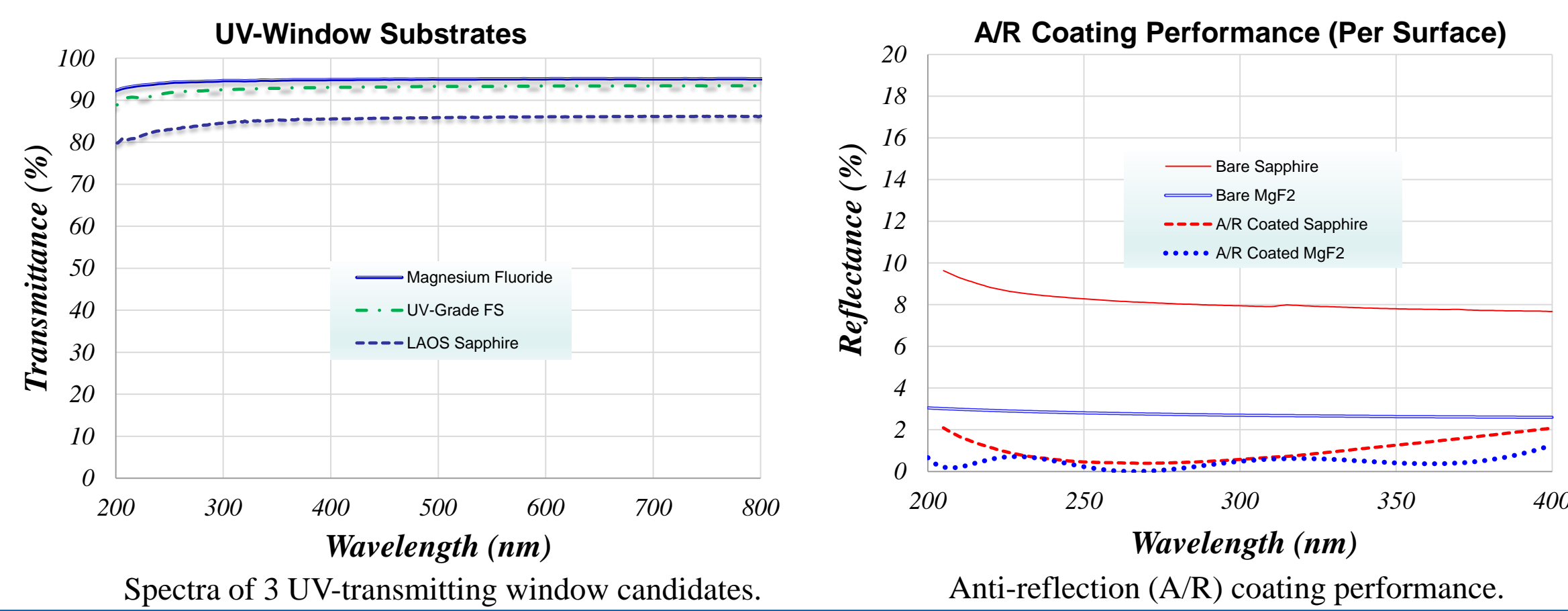


1-meter Physical Vapor Deposition chamber for depositing Al layer on bare DMD active area



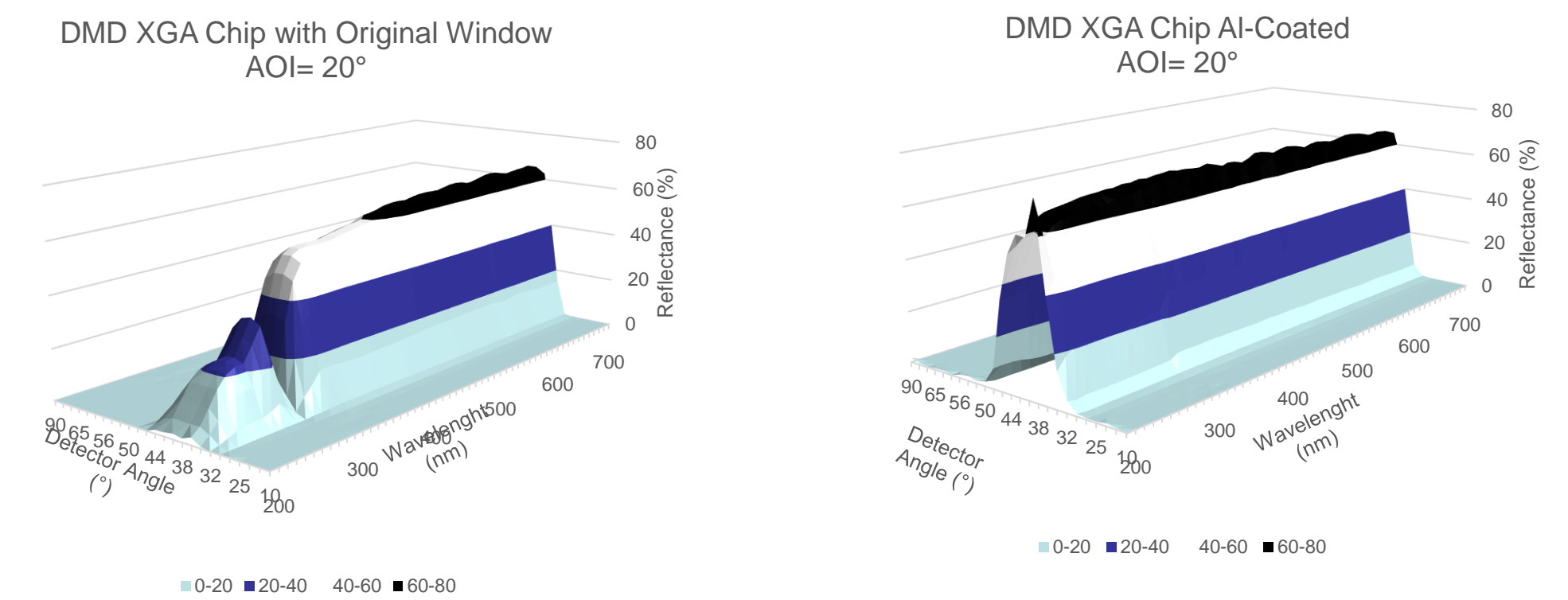
Bare DMD will be masked with only active area exposed and it will be inserted in the PVD chamber shown on left. Sample will be coated with an aluminum layer with thickness around 600 Å. Sample will be evaluated for measuring specular and Total Hemispherical Reflectance to evaluate performance in UV spectral range.

DMD with window removed (left) and mask (right) used during coating of active area with PVD layer of aluminum.

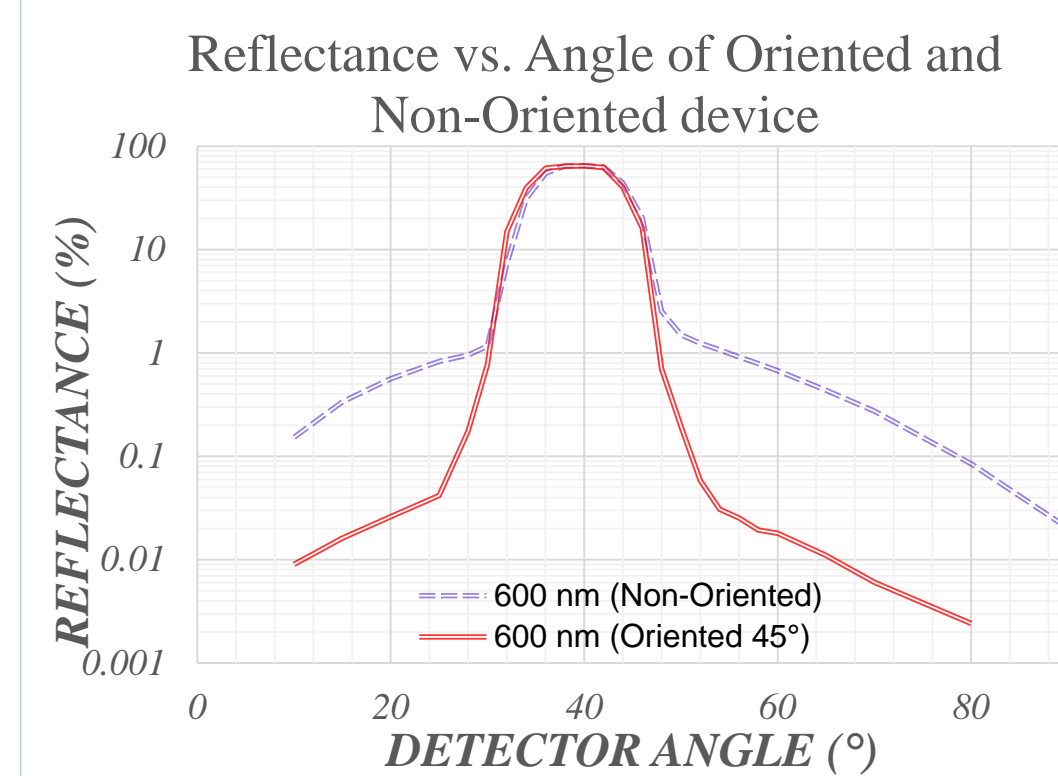


Spectra of 3 UV-transmitting window candidates.

### Anti-reflection (A/R) coating performance.



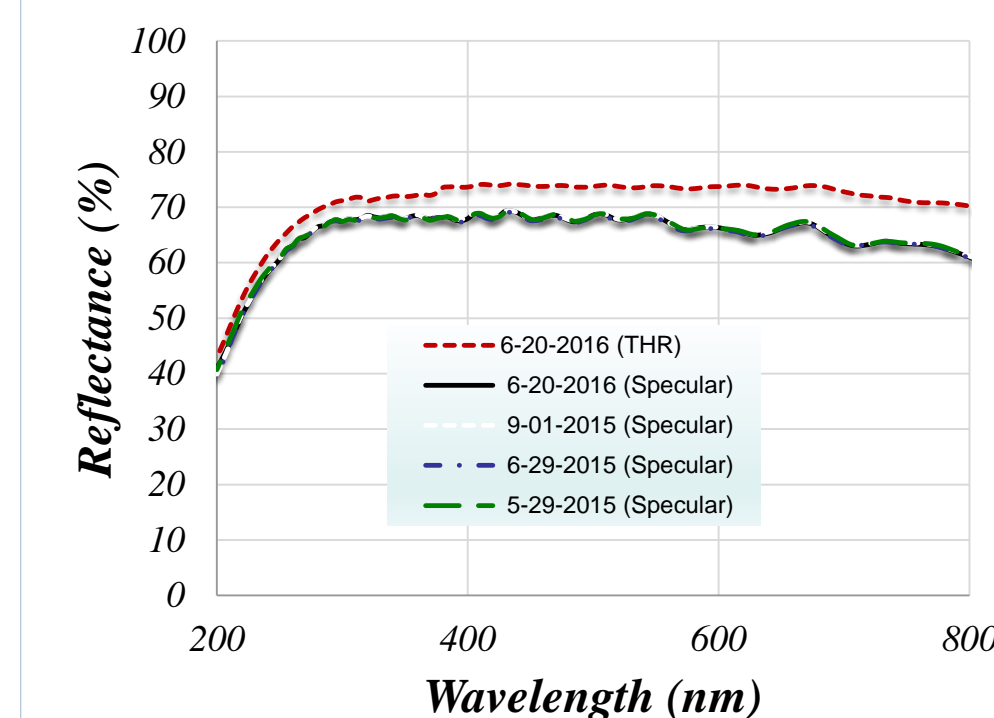
Reflectance versus wavelength at various detector angles for two DMDs. Notice the data on the right provides higher reflectance all the way down to 200 nm. This device was coated with a layer of Al. The device on the left has the TI original window as indicated by the drop in reflectance below 300 nm.



Reflectance diffraction pattern of  
DMD illuminated with light.

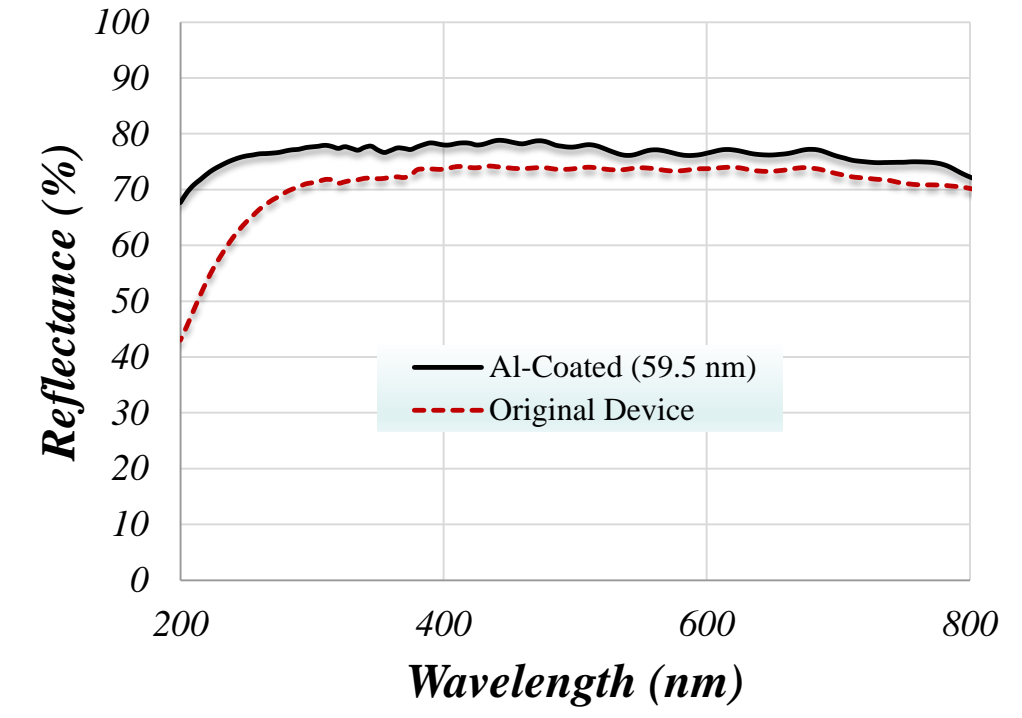
The diffraction of light produced by the regular array of micro-mirrors produces a scattering of the light that is preferentially along the vertical and horizontal edges of the micro-mirrors (see figure above). The graph on the left illustrates there is a factor of 10 less in scattered light intensity in the diagonal ( $45^\circ$ ) direction.

### Specular and Total Hemispherical Reflectance (THR) & Durability



The specular reflectance of a DMD shows **no-change** over a 1 year period. The red-dash curve represents the Total Hemispherical Reflectance (THR) or specular plus diffused reflectance of the same device.

### Total Hemispherical Reflectance UnCoated *versus* Coated DMD



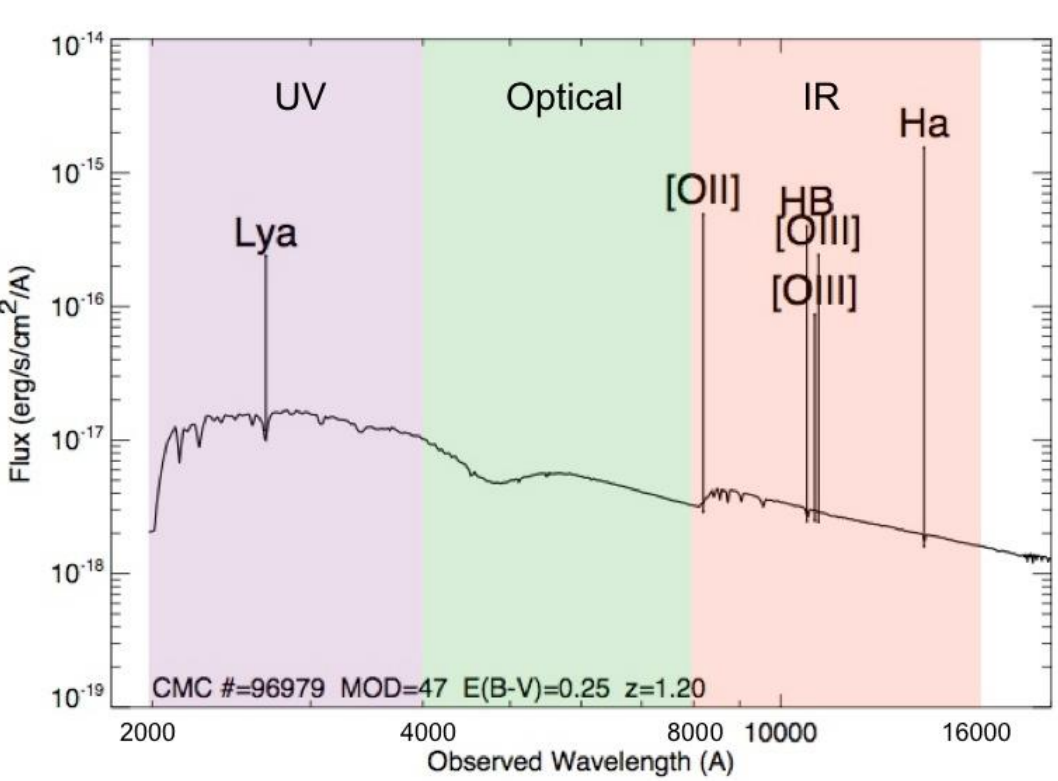
Comparison in reflectance of original *versus* Al-coated DMD active area. The recently coated device shows a 25% increase in reflectance at 200 nm.

## CONCLUSIONS

1. Replacing UV-transmitting windows of commercially available DMDs will provide UV capabilities.
2. Native reflectance of DMD is very stable over a year period. However, the reflectance may not be high enough for UV application.
3. PVD of Aluminum on DMD active area provides an increase in reflectance between 200-400 nm.

## REFERENCES

1. S. Jouvel, *et al.*, "Designing future dark energy space missions. Building realistic galaxy spectro-photometric catalogs and their first applications", A&A, **504** (2009).
2. K. Kearney and Z. Ninkov, "Characterization of a digital micromirror device for use as an optical mask in imaging and spectroscopy", SPIE, **3292** (1998).
3. K. Fourspring, "Assessing the Performance of Digital Micromirror Devices<sup>TM</sup> for use in Space-Based Multi-Object Spectrometers", Ph. D. Thesis, Rochester Institute of Technology (2013).



The flux distribution of a typical galaxy at  $z \sim 1$  shows strong emission lines (used to estimate precise red-shift and oxygen abundance), strong UV flux contribute by newly formed stars and ionized gas (used to simulate stellar age and metallicity), the 220 dust extinction feature, and absorption lines (used to detect neutral gas, stellar winds, and galactic outflows).

**DMD are commercial micro-electro-mechanical systems, consisting of millions of mirrors (each having dimensions of 13.7x13.7  $\mu\text{m}$ ) which can be individually addressed and tilted into one of two states ( $\pm 12^\circ$ ) along the diagonal direction. The array fill factor is 92%. These devices were developed by Texas Instruments (TI) to create binary patterns in video projectors, in the visible range. A Discovery Kit (shown on right) consists of the DMD, a controller board, and a cable connecting the two.**

